FINANCIALLY EFFICIENT MANAGEMENT OF SEWER FLOODING DUE TO BLOCKAGES

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Abstract
Each year over 100 000 blockages occur within the sewer network in England and Wales. The number of properties internally flooded each year due to sewer blockages is equal to the number caused by hydraulic overload, but historically nearly all the focus and expenditure has been on preventing those events caused by the latter. Achievement of the AMP4 targets for hydraulic overload flooding could potentially result in blockages accounting for an even higher proportion of flooding events and lead to the industry increasing the focus on their reduction.

In preparation for this new situation and the immediate requirement for water companies to achieve stable performance, Ewan Group has been working with several companies to develop sewer cleansing strategies to control the number of sewer blockages. These strategies have utilised a catchment-based model to determine the optimum balance between reactive and proactive expenditure, and the level of service that can be achieved for a given expenditure.

Following on from the high level modelling work, Ewan Group has implemented a programme of sewer cleansing to reduce the number of sewer blockages and simultaneously gain knowledge on how the network performs. This has been done by using two approaches; collating silt depths data prior to cleansing, and analysis of the effectiveness of the programme of works. These approaches have allowed the optimum sewer cleansing frequency to be established and identified those locations where sewer cleansing cannot improve serviceability, and further investigation is required.

The combination of these different strategies has allowed cost efficient programmes of sewer cleansing to be developed.

1. Introduction

Each year over 100 000 blockages occur within the sewer network in England and Wales and of these between 2% and 4% lead to internal flooding of properties. A similar percentage of blockages account for 30% of all pollution events and the remainder cause either external flooding (see Figure 1) or surcharging events.

Figure 1. Flooding due to a blockage

Ewan Group has been working with a number of water companies to develop maintenance strategies to reduce the serviceability failures relating to sewer blockages. The purpose of this paper is to provide an insight into this work and some of the lessons learnt.

2. Other Causes vs Hydraulic Overload

The cause of flooding events are categorised by the regulator, OFWAT, as either 'hydraulic overload' (HO) or 'other causes' (OC). The 'other causes' category, which includes blockages, collapses & equipment failures, accounts for 55% of all DG5 (internal property flooding) events annually, and 80% of these are due to sewer blockages [1]. Flooding caused by HO accounts for the remaining 45% of DG5s, but both historically and currently, the water industry's focus has been on resolving this cause of flooding, even though it accounts for a smaller proportion of flooding events.

Analysis of the AMP4 'Monitoring Plans' confirms a continuing focus on Hydraulic Overload, with 82% of the flooding outputs relating to this cause of flooding. This focus may be the result of an inherent assumption that HO flooding is generally more severe than flooding due to blockage, which occurs predominantly on small diameter pipes at the head of the system. However there are no official figures to support such an assumption.

The delivery of the AMP4 business plans will see the proportion of flooding events due to sewer blockages increase further and this should lead to the industry focusing more on their prevention.

3. Blockage Characteristics

Some sewer blockages are caused by customers disposing of inappropriate material into the sewers that even well designed sewers could not deal with (Examples include nappies, earth, dead pets, compact discs and car parts). Most are due to a combination of the discharge of material with the potential to cause a blockage and the physical characteristics of the system that make a blockage more likely to occur. These blockages will generally be composed of silt, roots or paper/rags. Fat is a particular problem as it is widely discharged by customers and frequently contributes to blockages even in well designed sewers.

Analysis of one company's serviceability data identified the following statistics relating to sewer blockages:

- 10% of sewers suffered from blockages over a 15 year period.
- 4% of sewers suffered from repeat blockages, but these accounted for 75% of all blockages recorded over a 15 year period.
- 2% of sewer blockages annually cause DG5s
- 12.5% of DG5s due to blockages suffered a repeat over a five year period.

These statistics indicate sewer blockages do only impact on a small percentage of sewers and that targeting sites with a history of repeat problems will lead to significant gains in performance. As every blockage risk will potentially cause flooding in the wrong circumstances it also demonstrates that gains in serviceability will not be achieved from just targeting DG5's caused by blockages.

4. Maintenance Strategies

There are two types of maintenance strategies which can be adopted to manage and reduce the number of sewer blockages and resulting serviceability failures:

- Reactive
- Proactive

Reactive

This is the type of maintenance that occupies the majority of sewerage operational crews' time and involves removing blockages when they have caused a serviceability failure (flooding, pollution or surcharging). This approach is still appropriate where the impact from a blockage will not be severe (no flooding) or the cost of preventing the problem proactively outweighs the damage cost associated with the blockage occurring.

This method does not allow any control over the number of serviceability failures due to blockages and it is difficult to manage operational workloads due to the unpredictable change in the number that occur from day to day or during a day. The combination of a peak in blockages and a constant workforce can lead to delays in response times increasing the severity of the serviceability failure.

Proactive

The best form of proactive maintenance is prevention at source, but this is not easily achieved due the variable nature of the customer. Nearly all the water companies have implemented advertising campaigns, including 'Bag it and bin it', and these have led to some successes. Nevertheless, a proportion of blockages continue to occur due to customers continuing to dispose of inappropriate debris into the sewerage system.

The most common form of proactive maintenance involves the removal of debris in the sewer prior to the development of a blockage and so reducing the likelihood of any subsequent serviceability failures. However, this approach requires data on which sewers are more likely to block in the future. This information can be provided using either a top-down Characteristic or bottom-up Historic Performance driven model or a combination of the two.

Characteristic driven models have started to be developed to determine the location and point in time when a blockage is likely to occur. These models are based on developing relationships between historic blockages and particular characteristic of the sewers experiencing blockages. This approach is appropriate for risk-based asset management planning providing a forward-looking view of how performance is likely to change in the future and a quantitative assessment of the impact of interventions over time to deliver the required level of service to customers and the environment.

Historic Performance driven models use historic blockage data to identify those sewers suffering from repeat blockages and assumes that, apart from where intervention has occurred, blockages will continue to occur in the future. This approach is simple and financially efficient due to both the low cost associated with identifying the locations to target and its accuracy at identifying those locations with a high risk of future blockages. Plus the benefits from the work are realised in a short period of time due to maintenance being targeted a locations with high frequency of repeat blockages.

The rest of this paper is based on how Ewan Group has used this Performance based approach to control sewer blockages.

5. Financial & serviceability model

The first stage of implementing a Historic Performance driven strategy was the development of a financial and serviceability model. The aim of the model was to predict the extent of a cleansing programme that can be identified from historic incident records. It then predicts the impact of this programme on blockage rate and resultant level of service failures (flooding and pollution). By comparing the cost of the cleansing programme with the cost saving of reduced failure incidents the model can demonstrate the cost benefit of various sizes of cleansing programme and allow selection of the optimum size of programme. A typical output from the model is shown on Figure 2 and the benefits from the different intervention options are evident.

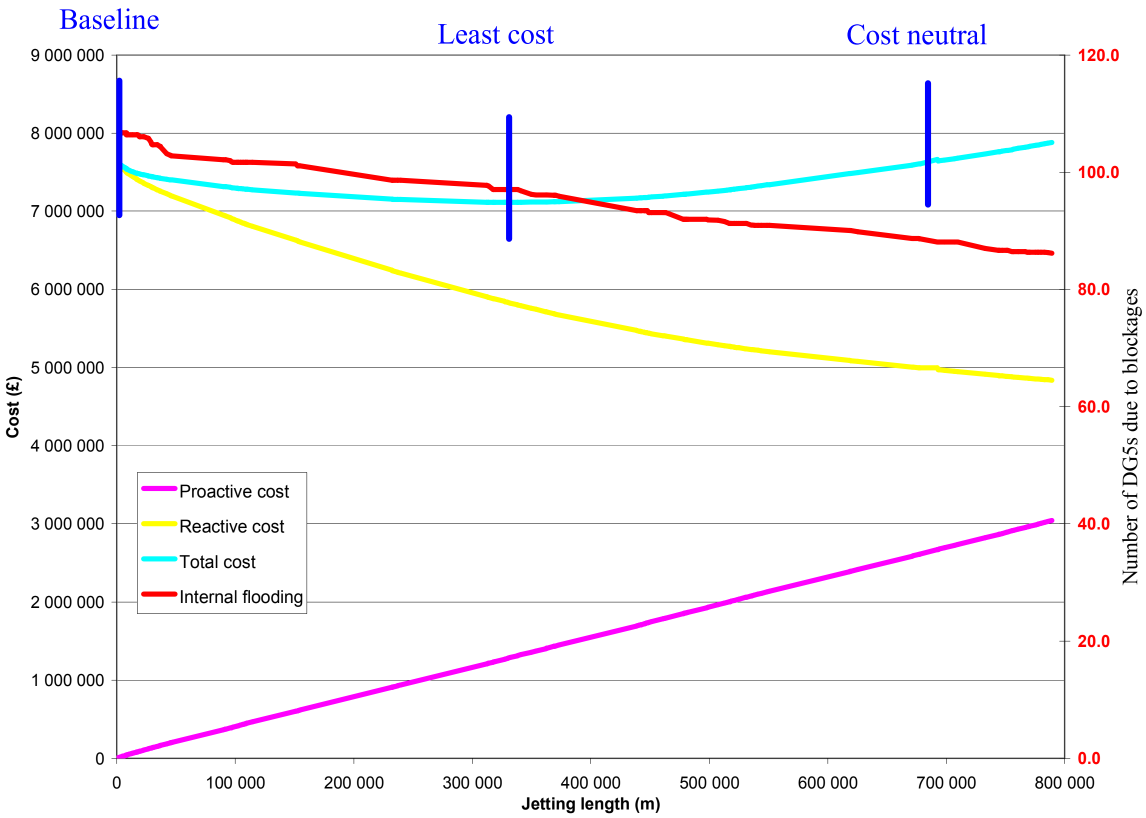
The model uses the following key parameters to predict the cleansing programme and resulting benefits:

- Number of hotspots
- Length of hotspot
- Cleansing frequency
- Change in blockage rate
- Change in service failures

These parameters were initially estimated based on engineering judgement, but have since been more accurately defined. The availability of data relating to these parameters from the development of the cleansing programme allowed relationships to be developed, using simple regression analysis, between known catchment criteria (sewer length, number of blockages, etc) and the above parameters. The increased accuracy of these parameters has increased the accuracy and confidence of the model output.

The confidence in the model was increased further through sensitivity testing of the different parameters, including damage costs, and validated against historic levels of serviceability and intervention.

Figure 2. Sewer blockages optimisation model



The model has been applied at the catchment level, which allows a cost benefit ratio to be determined for each catchment based on the implementation of a cleansing programme and the resulting change in serviceability. The catchments can then be ranked using the ratio to identify the catchments requiring cleansing first.

6. Programme of works

The determination of both the optimum cleansing programme value and the catchments where a cost benefit exists from implementing a programme of sewer cleansing, leads to the next step of identification of the individual sewers to be targeted with sewer cleansing. These assets were identified using a Geographical Information System linked to a Relational Database, and this allows the sewers suffering the highest frequency of blockage or causing the greatest serviceability failures due to blockages, to be identified. These sewers are known as 'Bad Actors', due to their poor performance.

The 'Bad Actors' were found by first linking every serviceability failure to a particular sewer using either operational information or identification of the sewer with the highest blockage risk within a predefined area from the incident. This then allowed the historic serviceability for each sewer to be defined and the 'Bad Actors' to be identified.

Operational personnel confirmed the identification of the 'Bad Actors' to ensure the problems were still current and no capital works had been completed to resolve the problem. They also assisted with identifying the scope of the cleansing and this provided a validation of the system used to identify the sewers.

The serviceability and financial effectiveness of this approach is based on the ability to identify the ideal repeat cleansing date. The cleansing date must be before the sewer debris creates a sufficient hydraulic restriction as to cause a serviceability failure but not so soon that debris has not built-up to a level to warrant the cleansing of the sewer. In an ideal world, the repeat cleansing would be completed just as a blockage has occurred and the upstream sewers have become surcharged, but without causing a serviceability failure. The determination of this repeat cleansing date also needs to be done in a cost effective manner.

Ewan Group has worked with a number of contractors to develop a process whereby the repeat cleansing date was based on the quantity of silt removed. The quantification of the silt depths by the contractor is based on the following combination of factors:

- Visual inspection of manhole.
- Number of pulls through the sewer before no further debris is removed.
- Vibration and speed of travel of the jetting hose.
- Noise from vacuum pipe.

The reported silt depths were recorded each time the sewer was cleansed and this data was stored against each sewer length on the programme. The repeat cleansing frequencies were defined from a criteria matrix, which considered the level of debris removed, and its form (fat, silt, roots, etc). The collection of this data allowed a picture to be developed on how debris built up on each sewer after it was cleansed. Analysis of this data showed the average level of debris reduced the second time a sewer was cleansed, which allowed the repeat cleansing frequencies to be extended, and this is demonstrated on Table 1. This data was used to identify the optimum cleansing frequency for each sewer after it was cleansed three or four times, which avoids the future need to collect the silt depth data.

Table 1. Average cleansing frequency for each repeat event

Cleansing Event	Average cleansing frequency (Yrs)
First	1.056
Second	1.626
Third	1.592

The change in debris levels on the second and subsequent cleansing events was probably due to the sewers not being cleansed for tens of years prior to the first cleansing event, apart from when they become blocked. The first cleansing event removed this backlog of debris, the second event established a baseline and third event revealed the true rate at which debris built up. For larger sewers, this true rate of debris build was not observed until after the third or fourth cleansing events and this was believed to be due to the upstream sewers washing debris into the main sewer after the first cleansing event.

The success of this approach required the silt depth to be recorded consistently across all contractors and across separate teams for an individual contractor. This was achieved by running training sessions with all the teams involved and monitoring of the data returned by comparing it with the previous recorded silt depths.

The assignment of a particular cleansing frequency to a location is supported by a periodic effectiveness analysis. The analysis consists of identifying those serviceability failures which occur on or close to sewers associated with the sewer cleansing programme. This process identifies those locations where cleansing frequencies need to be increased or sewer cleansing is not appropriated for preventing serviceability failures, and further investigation is required using CCTV survey to identify the underlying cause of the problem.

The use of the sewer cleansing process to improve serviceability and measure the debris removed, plus post monitoring of the cleansing effectiveness has removed the need to CCTV survey every location. This allows resources to be used to maximise the serviceability of the network and CCTV to be targeted at locations where a more detailed understanding of the problem is required. The effectiveness assessment has also enable the benefits from this Historic Performance driven strategy to be quantified and they are shown on Table 2. The benefits show this approach is successful at preventing blockages at locations with a history of failures.

Table 2. Effectiveness of Historic Performance Driven Sewer Cleansing Strategy

Type of serviceability failures due to blockage	Percentage of locations **not** suffering failures after cleansing
Surcharging	85%
External Flooding	96%
Internal Flooding	98%

Other elements of work which complemented and supported the main programme of sewer cleansing included:

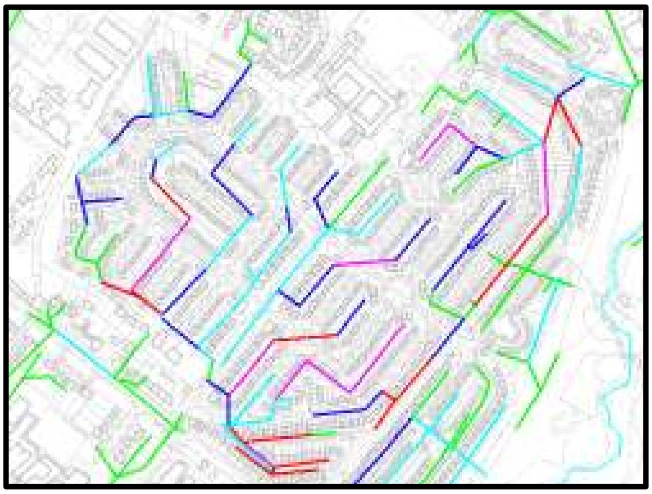
- Identification and construction of access chambers at locations where sections of the network cannot be accessed. This issue was particularly relevant on section 24 sewers.

- Cleansing teams identifying the layout of section 24 sewers. Where operational personnel identified the repeat blockage problem was associated with a section 24, the cleansing teams would identify the layout of the sewer and return the necessary data to enable it to be plotted on GIS.
- The cleansing teams where issued with “Bag it and bin it” and “Fat disposal” fliers to allow them to issue them to individuals believed to be responsible for excess sewer debris (fast food shops, supermarkets, food processing factories, etc)

7. Future

Developments in GIS functionality have recently enabled Ewan Group to build on the ‘Bad Actor’ analysis. The use of a network tracing tool has allowed the number of Blockages associated with the assets within 50m up and downstream of every sewer to be determined. The outputs from this analysis has enabled the scope of the sewer cleansing to be better defined and allowed locations to be identified for cleansing where each individual sewer has a low number of blockages but they add to a significant problem area. The outputs from this analysis are shown on Figure 3.

Figure 3 – Trace analysis output



Key – Number of blockages
Grey = 0, Green = 1-4, Cyan = 5-9,
Blue = 10-14, Red = 15-19, Magenta = 20+

The success of Historic Performance models or the implementation of similar strategies described in this paper, all depend on the quantity and quality of serviceability failure and intervention data. This data needs to be recorded at the individual asset level and in a consistent, complete and accurate manner. Datasets of this quality are starting to be developed, but are generally for only a short period of time.

8. Conclusion

This paper has provided some of the background to the challenge faced by the water companies in controlling the number of flooding events caused by sewer blockages. It has also identified that unless proactive measures are put in place, then the proportion of flooding events caused by blockages will increase with the outputs from the large programmes of works in AMP4 to prevent hydraulic overload flooding.

It has also provided an insight to the work Ewan Group has been undertaking for a number of water companies in developing strategies to reduce the number of sewer blockages, and thus its impact on the customer.

References

1.National Audit Office, Out of sight, not out of mind – Ofwat and the public sewer network in England and Wales, January 2004.